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(54) METHOD OF PREPARING MEAT SUBSTITUTES

(71) We, GENERAL FOODS CORPORATION, a Corporation organized under the laws of the State of Delaware, United States of America, of 250 North Street, White Plains, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to producing food products of fibrous nature and more particularly to a process for preparing dense, heat irreversible, proteinaceous material having a fibrous nature simulating the muscle of animals or flesh of fish hereinafter described as meat.

The food industry for many years has attempted to provide high protein, low cost fibrous proteinaceous material as a substitute for meat. Meat systems in a simplified form have been considered to be comprised of a system of fibers held together by a suitable binder. Thus, synthetic textile fiber technology was applied to the preparation of protein fibers which later may be formed into a single meatlike mass employing a suitable binder. A recent example of binding spun fibers is disclosed in United States Patents 3,498,793 and 3,559,561. A protein solution is forced through spinnerettes into an acid bath forming fiber. The spun fibers are then compressed into a solid mass and bound to resemble natural meat products derived from the muscle of animals.

The basic patent giving means of spinning proteinaceous fibers is United States Patent 2,682,466. Since then numerous patents have issued using spinnerettes.

While spinning techniques produced satisfactory fibers and when bound acceptable meat products, extensive equipment investment and careful control of processing variable is required with the resulting disadvantage that the final products produced are relatively expensive.

A means of producing fibrous protein without employing spinning techniques is disclosed in United States Patent 3,047,395, which discloses rapidly heating a protein slurry, either animal or vegetable, in a finely divided state to a temperature of 300° to 400°F under continuous agitation to cause coagulation of the protein into a fibrous mass. Rapid cooling of the protein results in a shred-like fibrous material which is recovered at rather low yield.

Recent techniques have been devised for producing a low cost, expanded vegetable protein material for use as a meat substitute. Proteins such as soy are subjected to elevated temperature and high pressure and forced through a die to produce an expanded mass or rope of proteinaceous material. The sudden expansion from high pressure to atmospheric pressure causes an expansion in the direction of flow which produces the appearance of fibers. Illustrative techniques are disclosed in United States Patents 3,480,442, 3,488,770 and 3,496,858.

Another technique for forming meatlike products is taught by United States Patent 3,102,031 wherein a gluten dough is used in producing an uncooked ground meat-type product.

This invention produces low cost, heat-set fibrous, high protein materials resembling the muscle of animals or flesh of fish. A variety of fibre configurations, simulating natural meat or fish, are prepared by controlling process and formulation variables. These fibrous configurations can be described as short and unaligned, long and unaligned, long and aligned and long, fleshy and aligned. The fibrous proteinaceous material has a more meat-like appearance than offered by current high pressure expanded extrudates and provides a simpler and less costly process than those employing spinning of protein and provides much greater yields of fibrous product than obtained by employing a slurry as in United States Patent 3,047,395.

The present invention involves the compression and orientation of a high protein material followed by the

simultaneous orientation and coagulation of the material into fibers. The oriented and coagulated protein material is then recovered. In one embodiment where a pressure drop is minimized, any substantial increase in volume or puffing is also minimized. A substantial increase in volume or puffing is an increase in volume of greater than 20%.

Orientation and coagulation of the protein is accomplished simultaneously so as to coagulate or heat-set the protein as it is stretched or elongated and formed into a dense, a shred-like, continuous fibrous condition. This is accomplished by compressing a dough of heat-settable or coagulable protein in a chamber of decreasing volume, so that the pressure exerted by the reduction in volume forces the dough in the direction of the chamber outlet and simultaneously densifies and presses the dough against a heated surface thereby heat coagulating the protein and forming thermally irreversible fibers as the dough is stretched and/or elongated in a direction toward the outlet of the channel. The irreversible fibrous dough is then recovered and in one embodiment with minimal increase in volume and in the other without a substantial increase in volume. In this first embodiment this invention provides a layered, thermally irreversible, fibrous meat-like material without the use of spinning or puffing techniques. If desired the meat-like material may be readily pulled apart into shreds. In the latter embodiment when some expansion is permitted the invention provides an expanded aligned, thermally irreversible, fibrous meat-like material which is less spongy and more aligned than commercially texturized vegetable proteins.

While the orientation and heat-setting employed in the present invention is related to principles set forth in United States Patent 3,047,395, the yield of final fibrous material is significantly improved. The product of this invention is a distinct improvement over that disclosed in United States Patents 3,102,031, 3,480,442, 3,488,770 or 3,496,858 in that the proteinaceous material is extremely fibrous in nature resembling that obtained employing spinning techniques, need not be puffed as present TVP (Texturized Vegetable Protein) and does not resemble the proteinaceous uncooked granules of United States Patent 3,102,031 which lack fibrous characteristics.

According to the invention there is provided a process for preparing a fibrous product simulating meat which comprises adjusting the moisture content of a ground mixture containing at least 35% heat coagulable protein on a dry basis to 20% to 65% water, blending to a dough, compressing the dough in a chamber formed by a channel of screw rotating with an outer wall heated to at least 250°F. in which the volume of the channel between flights of the screw is decreased at least 3/2 from feed to discharge of the chamber to simultaneously degas, densify, and elongate the dough and heat set the dough to a thermally coagulated fibrous condition and expelling the set dough while maintaining a pressure drop to atmosphere of less than 500 psi.

In one embodiment there is provided a process for preparing a fibrous product simulating meat which comprises adjusting the moisture content of a ground mixture containing at least 35% heat coagulable protein on a dry basis to 25% to 65% water, blending to a dough, compressing the dough in a chamber formed by the channel of a screw rotating within an outer wall heated to at least 250°C. in which the volume of the channel between flights of the screw is decreased at least 2/1 from feed to discharge of the chamber to simultaneously degas and densify the dough, elongate the dough and heat set the dough into a thermally coagulated fibrous condition and expelling the set dough from the chamber without use of a die while maintaining a pressure drop below 100 psi without substantial puffing of the set dough and while maintaining the fibrous condition of the dough.

In another embodiment there is provided a process for preparing a fibrous product simulating meat which comprises adjusting the moisture content of a ground mixture containing at least 35% heat coagulable protein on a dry basis to 20 to 49% water by weight, and blending the mixture to a dough, compressing the dough in a chamber formed by the channel of an auger rotating within an outer wall heated to at least 250°F. in which the volume of the channel between flights of the auger is decreased at least 3/2 from feed to discharge of the chamber to simultaneously degas and densify the dough, elongate the dough and heat set it into a thermally coagulated fibrous condition and forcing the set dough through a die wherein the pressure drop to atmosphere is less than 500 psi causing some expansion of the set dough and recovering a fibrous product which when dry has a density of greater than 0.65 g./ml and a hydration of not more than 2 g. H_2O/g. solids when soaked 1/2 hour in water at 50°C.

Thus meat-like fibers of the present invention are prepared by subjecting a moist, heat-settable fiber forming proteinaceous material to a simultaneous compression, heat setting and elongation in

a chamber of decreasing volume to form a continuous fibrous structure which may be further processed by drying, hydrating or by other recognized techniques to produce a meat or fish substitute useful in processed foods.

A moist dough of coagulable proteinaceous material is compressed into a unitary body within a chamber of decreasing volume formed by a heated outer wall and an internally rotating screw (auger). Volume is reduced by increasing the number of flights per unit length within the range so that a minimum reduction of 3/2 (3 volumes to 2 volumes) is obtained. A reduction of 2/1 to 5/1 is preferred for the process where there is no pressure point at the exit which gives minimum expansion. A reduction of from 3/2 to 5/1 can be used where there is a greater pressure reduction giving expansion. The pressure exerted by the reduction in volume of the chamber between the flights of the screw forces a compaction of the protein normal to the channel of the screw aligning the protein in the direction of the channel. Simultaneously, the heated outer wall transfers sufficient heat to the compressed and stretched mass of protein to plasticize the material and heat set the material into a dense fibrous mass which is ejected from the chamber. The heat set material can be ejected without a substantial increase in volume over that present in the channel just prior to ejection. The clearance between the heated surface, normally cylindrical in nature, and the rotating screw is adjusted generally to minimize back-mixing of the proteinaceous material and to quickly heat throughout, stretch and orient the proteinaceous mass in a direction parallel to the auger channel.

Pressure is necessary to compact the proteinaceous material to a point where it is substantially free of voids and to ensure rapid heat transfer, by conduction, from the heated surface to the proteinaceous material. The pressure in at least one embodiment is maintained at the minimum amount necessary to accomplish compression and to force the material through the chamber of reduced volume since excessive back pressure disrupts the oriented proteinaceous mass and destroys the fiber condition of the protein. For this embodiment dies normally employed to develop back pressure sufficient to cause expansion of the extrudate, to a region of lower pressure, are not employed as disruption of the oriented mass can occur in an expanded form. The fibrous nature of the protein is formed, at least in part, within an extruder and does not require the large pressure drop across a die to develop the appearance of fibers, and also a characteristic sponginess so typical of the prior art products of United States Patents 3,480,442, 3,488,770 and 3,496,858. The extruder chamber reduction also provides a frictional resistance to the flow of proteinaceous material which causes elongation of the material in the direction of extrusion. As the fibrous nature of the protein is developed, the heat transferred from the heated surface irreversibly sets the protein into a fibrous mass. Where conventional dies are employed at the end of the extruder the pressure drop to atmosphere from the greatest pressure developed at the feed side of the die is minimized to limit expansion thereby reducing sponginess and to reduce disorientation of the mass and is under 500 psi, preferably less than 200 psi, the time of heating being less than 3 minutes.

Thus depending on whether or not a die is employed expansion can be either avoided or minimized. Depending on whether a die is employed the product is in two different forms but both are fibrous and both superior to those of the art.

As indicated and particularly for a non-expanded product the chamber surface also provides a frictional resistance to the flow of proteinaceous material which causes stretching or elongation of the material in the direction of the screw channel thus forming a dense, layered, continuous fibrous product.

In a non-expanded form the product issuing from the chamber does not pass through a die and is preferably recovered avoiding pressure drop of any kind thus ensuring that back pressures, other than the resistance of the heated wall and screw do not cause disruption of the oriented or fibrous nature of the protein. Conventional dies employed for puffing are not employed for this embodiment but where shaping is desired a constriction of the type disclosed in United States Patent 3,559,561, can be employed to shape the material while minimizing puffing and disruption of the fibers. The pressure drop to atmosphere from the greatest pressure developed in the mass compressed by the rotating auger and the wall for this embodiment should be minimized to limit expansion or puffing to 20% or less, preferably to 10% or less and preferably below 5% volume increase, the time of heating being less than 3 minutes. Pressure drops well below 100 psi are typical.

The thermally irreversible, dense, fibrous protein material once discharged from the chamber may be dried, hydrated, or further cooked by any number of art recognized procedures. The product is useful for foods such as a substitute for meat or fish. The term meat as used herein is intended to

include flesh products of animals, birds and fish.

The proteinaceous material employed in this invention must have several critical properties. It must contain a minimum percentage of undenatured protein, that is protein that has neither been heat-treated nor otherwise processed to the point where it is no longer coagulable. The protein must also be capable of forming a dough (particulate or not) which can be stretched and pulled or elongated into a fibrous structure.

The proteinaceous dough, depending on its consistency, may be fed to the extruder in a continuous mass or may be subdivided into discrete particles for convenience in feeding.

The concentration of the protein necessary for fiber formation will vary according to the quality and source of the protein. Raw meat, fish and vegetable protein materials can be employed. Suitable vegetable protein sources are soy bean meal, peanut meal, cottonseed or other vegetable protein materials generally recovered as by-products from oil extraction. Full fat proteinaceous sources may be employed but concentrated sources of the protein material are preferred to maximize the protein content of the dough. The muscle of animals, flesh of fish, soy isolate, gluten, egg albumen, dairy products such as dry milk powder, whey, wheat flour and other protein sources are useful. Cheap meat, poultry or fish not having utility for direct sale to consumers such as poultry paste recovered from laying chickens are a preferred source of animal protein. Proteins such as protein isolates, defatted soy flour and particularly wheat gluten are preferred vegetable derived proteinaceous sources.

Proteinaceous materials are sub-divided (preferably flours of these materials are employed) and mixed to form a moist dough having a moisture content of between 20% to 65% water, as its basis. Flours having a particle size 80 mesh (United States Standard Sieve) or finer, are particularly good for forming a uniform initial dough especially for the non-expanded product. Where meat materials are employed, it is necessary to partially dehydrate the meat by known drying methods or mix the meat with dry vegetable protein sources or other materials, to reduce the moisture content required for processing. of course, heat treatment on drying of meat or fish will cause denaturization and therefore, it is preferred to employ meat only as an additive or supplementary source of protein to dry vegetable protein which will comprise a major portion of the dough.

Gluten is the preferred vegetable-derived protein. It is generally preferred to employ a minimum concentration in the dry mix of about 20% to a maximum of about 75% wheat gluten. The upper limit is dictated by the inability to mix compositions containing a greater amount of gluten while the lower concentration has been found to produce little fiber formation in the absence of other heat coagulable proteins. The lower levels of gluten or no gluten at all may be employed provided the dry weight basis of fiber forming, heat coagulable protein is maintained above 35% by weight (dry basis) of the dough.

Oil seed flakes are usually not employed in the process of this invention particularly for the dense, non-expanded product. Flakes or coarsely ground oil seed can appear in the final heat treated product in its original particulate form thus detracting from the fibrous character of the product. Although some carry through is evident when soy grits are employed the grits produce an acceptable product. It is preferred, however, to employ protein flours having a particle size less than 80 mesh (United States Standard Sieve). Furthermore, while water soluble protein (WSP) or nitrogen solubility index (NSI) of the protein can range from 25 to 85, protein having an NSI of 50 or above, preferably 60—75 is preferred, particularly soy.

Other materials may be mixed with the proteins. For example, carbohydrates such as starch fillers, colors, fats and other flavoring ingredients may be added to the proteinaceous material. Wheat flour has been found to be an extremely useful additive since it provides some gluten useful in fiber development and is readily cooked and gelatinized during the process to produce a desirable flavor and texture in the product. However, defatted soy bean flour also provides sufficient carbohydrates and a better protein value in the finished product.

The proteinaceous materials, fillers, and other additives are mixed with water to form a dough. The ingredients should be mixed in a heavy duty mixer such that at least some fibers are visually apparent when the dough is pulled. The dough can be a single mass such as that produced in the pastry art or can be particulate such as that produced in the pasta art. The moisture content of the dough may vary within limits of from 20% to 65% by weight but preferably is maintained at 25% to 49% by weight for doughs containing a major amount of vegetable protein.

It is important to mix the material with water sufficient to distribute the water as uniformly as possible in the proteinaceous material.

Close inspection of the mixed material

can reveal a fibrous content in the dough which is a clear indication that the particular dough is capable of forming fibers within the extruder particularly for the non-expanded product. The mixing time necessary to form the fibrous dough is not critical provided generally fibers are present when the dough is stretched.

The fibers are further developed and set by subjecting the moist fibrous proteinaceous dough to compression in a chamber of decreasing volume formed by a heated outer wall and a rotating screw such that the pressure exerted by the reduction in volume as the outlet of the chamber is approached densifies the dough but where there is no die at the outlet there will be no substantial expansion on exit from the chamber as the pressure does not exceed 100 psig at the outlet. The compression forces the dough into a dense unitary body conforming to the chamber formed between the screw and the wall. The compression removes voids, expels air and forms a dense proteinaceous mass. Simultaneously, the compression against the heated outer wall allows rapid heat transfer into the mass plasticizing the mass as it is forced toward the outlet of the extruder. The continuous turning of the screw, the resistance of the heated wall and the volume reduction cause a stretching of the plastic mass forming a fibrous texture which is usually aligned in the direction of the channel of the screw and simultaneously the fibers are heated to the point of forming a heat irreversible proteinaceous mass. The fibers are thus simultaneously stretched and oriented in layers or planes normal to the heated surface. The heat set fibers are then expelled from the extruder without puffing so as to retain the dense meat-like structure formed within the extruder.

Formation of the fibers is conveniently done by feeding a premixed dough to an extruder of the type normally employed in the plastics industry having a minimum clearance between the periphery of the screw and the heated wall and preferably having a minimum clearance between the base of the channel formed by the flights of the screw and the heated wall. By this design, the heat transfer surface area to volume of the protein mass being treated is maximized. The extruder should be designed to provide a reduction in volume from feed to discharge in the screw channel, of from 3/2 to 5/1, preferably 2/1 to 5/1, fold with the reduction being at least 3/2 for a more expanded product.

The wall is normally heated to a temperature of at least 250°F. and preferably to an average temperature of 280°F. or greater. It is preferred to employ multiple zones of heat to provide proper temperature control throughout the barrel of the extruder. Thus the first zone near the inlet of the extruder may be heated to at least 250°F. and then one or more zones closer to the outlet may be heated to a temperature of 280°F. or greater. The heated surface cooks the carbohydrate content of the dough and raises the temperature of the dough to a point where the protein coagulates. Simultaneously, the screw rotating in relationship to the heated wall causes a stretching effect aligning the material within the screw channel as the protein is being coagulated. For a denser product the rotating screw and heated wall are closely aligned to limit slippage or back-mixing during stretching and coagulation of the fibers.

The minimum speed of screw or auger rotation is determined by the speed necessary for a given extruder to prevent charring or browning of the proteinaceous material as it is being treated. The exact operating conditions are not critical provided sufficient reduction in volume is available to ensure proper compression to a dense mass, stretching and coagulation of the protein. If desired, the screw of the extruder may be heated to further increase the surface area present for a given mass of proteinaceous material, and may be further designed to provide a first mixing stage wherein the temperature of the proteinaceous mass is increased to a point incipient to coagulation where-upon the screw is designed to provide a reduction in volume to compress, elongate and orient the protein during coagulation. The first mixing stage may also be employed to mix ingredients and form the fibrous dough. Thus large amounts of material may be mixed initially in deep flights in a screw and upon formation of the dough and reaching coagulation temperature the volume of the screw channel reduced to maximize the heated surface to mass relationship during elongation and coagulation of the protein.

An expanded dense product, prepared by the process of our invention, is substantially less puffed and less spongy than commercially available texturized vegetable protein.

Presently available known "expanded" commercial texturized vegetable proteins have an absolute density of 0.22—0.64 g/cc and a hydration rate of above 2.0 g H_2O/g TVP.

The reduction in volume within the extruder has been found to have an appreciable effect on the kind of fiber produced. As the volume in the channel is decreased, longer, stringier fibers are developed. In extruding a given formulation, such as used in Example I, a

2:1 reduction in volume gives a fibrous fleshy meat-like strip having more tissue layers whereas a 5:1 reduction in volume gives a material with fewer layers but having longer fibers.

The total moisture content of the dough entering the extruder (as is) may vary from 20% to 65% water.

Higher moistures, usually around 45% are useful in preparing a fish-like texture having relatively short unaligned fibers. It is believed that the high moisture content allows greater mixing of the plastic mass during coagulation and dilutes the protein content of the dough sufficiently to reduce the degree of stretching and alignment of fibers during coagulation. A good seafood texture is obtained employing a dough containing about 20%—45% wheat gluten and about 38%—49% water processed at a temperature of about 275°F to 325°F using a 2/1 reduction in volume during coagulation. The fiber length is increased by using higher amounts of wheat gluten and higher temperatures within the preceding range without orienting the fibers.

In preparing a denser product of an aligned, fibrous protein, a dough consisting of wheat gluten levels of 45%—70% (dry basis); 25%—38% water is processed at temperatures of 275° to 390°F using screw volume reduction of 2/1 to 5/1. Decreasing the volume reduction of the screw, within the preceding range, provides a fleshy, aligned, fibrous product, while increasing the volume reduction provides a long, stringy, fibrous product. These aligned structures are most applicable in simulating naturally existing meat-type muscle structures.

The dense product, prepared by the process of one embodiment of the invention, is substantially unpuffed (less than 10% and preferably less than 5% volume change on issuing from the extruder) although surface and internal bubbles may be present and are believed to be caused by evaporation of water. Absolute density measurements made by weighting texturized protein, incorporating this protein in 250 ml of purified sand and measuring the displacement of sand have indicated that known commercially available "dense" TVP has a density of 0.5 g/cc whereas the products produced by the invention, prepared as in Examples I and VIII, have densities of 0.8 and 0.6 g/cc, respectively.

The following Examples are illustrative of this invention, but not intended to limit it. In all cases illustrated by Examples I to XI, the extruders were run without a die or torpedo to prevent puffing and disruption of the product.

EXAMPLE I

A mixture of wheat gluten (60%), ground soy grits (25%), wheat flour (12.6%), ammonium carbonate (0.4%) and salt (2%) was dry blended, and an amount of water equal to 30% of the final weight of the mix was added. The total mix was blended in a mixer for 20 minutes. The blend was then force fed into a 3/4" laboratory extruder having a 25:1 L:D (length to diameter) ratio screw. The die section and torpedo were removed to prevent pressure drop causing a volume change or disrupting the continuous aligned fibrous product. The extruder barrel consists of three heating zones with barrel temperatures of 244°F., 310°F. and 330°F. from inlet to outlet, respectively. The 2/1 screw i.e. at the end of the screw there are two flights per unit length for every one per unit length at the beginning of the screw, producing a 50% volume reduction within the extruder, was rotated at 40 RPM. Dough at 55°F. entering the extruder, remained therein for approximately 55 seconds and exited at 255°F. (29 gms/min at 17% moistures). The exiting product was a long continuous substantially unpuffed ribbon with a fibrous, aligned texture. Upon hydration in boiling water, the product resembled strips or shreds of chicken, pork or veal.

EXAMPLE II

Example I was repeated except ammonium carbonate was removed from the formulation. The resulting product on rehydration was found to be fibrous and meat-like.

EXAMPLE III

A formulation containing a 20% wheat gluten, 65% soy grits, 12.6% wheat flour, 2.4% salt, all on a dry basis, was mixed with water to form a dough of 30% moisture and processed as in Example I. A continuous strip of product was obtained which on hydration had visible meat-like fibers present.

EXAMPLE IV

The dry blend was prepared of 60% soy isolate, 25% ground soy grits and 15% wheat flour. Sufficient water was added to the blend to prepare a 35% moisture dough which was mixed in a blade mixer for 20 minutes. The dough was extruded employing the extruder used in Example I using a 5/1 screw operating at 70 RPM. The dough was fed to the extruder at 70°F and the heating zones on the extruder were set at 290°F, 300°F and 310°F from feed to discharge, respectively. A continuous strip of material was produced with a pressure at the discharge of the extruder less than 150

PSI. On rehydration, the product was found to be fibrous resembling chicken skin.

EXAMPLE V

A dough was prepared in a blade mixer composed of 33% chicken solids derived from old egg-laying hens, 50% wheat gluten, 11% ground soy grits and 6% wheat flour. The chicken solids are commercially available in frozen form and contain 67% moisture which was sufficient with the other dry ingredients to produce a final dough of 40% moisture. The frozen chicken solids were chopped into small chunks and placed in a mixer and mixed with the dry ingredients for 25 minutes. The resulting dough was extruded using a 2/1 ratio screw at 70 RPM. Uniform zone temperatures of 300°F were employed. A continuous strip of material was obtained which was uniform, evenly cooked and highly fibrous resembling chicken meat when rehydrated.

EXAMPLE VI

Frozen chicken slurry 33% solids was freeze-dried, in a laboratory dryer for six hours to a moisture content of 39%. The freeze-dried chicken was then extruded in the equipment employed for Example I using a 2/1 screw and an RPM of 80 to 100. Product was recycled during extrusion to increase the temperature until there was obtained a strip of very fibrous material in nature but with little fiber alignment due to recycling.

EXAMPLE VII

Chicken slurry prepared from ground laying hens was kneaded with wheat flour to produce on a dry basis a composition of 54% wheat flour, 46% chicken solids having a moisture content of 45%. The mixture was extruded using a 3/4" extruder as in Example I. The 2/1 screw was rotated at 90 RPM. The barrel temperature profile was maintained at 290°F producing a fibrous partially aligned meat-like product.

EXAMPLE VIII

To 67 parts of defatted soy flour (60—75 NSI) was added 33 parts of water in a blade mixer. The material was mixed for 20 minutes resulting in a particulate dough having a fibrous character. The dough was force fed to the extruder employed in Example I. The dough was transferred through the extruder employing a 4/1 screw turning at 60 RPM. The temperature of the extruder barrel was maintained at 300°F at the inlet end 325°F at the outlet of the extruder. The extruder product was fibrous. When hydrated the extrudate had the appearance of veal.

EXAMPLE IX

A dry blend similar to Example I was prepared. To the dry blend was added an amount of water equal to 45% by weight of the resulting mixture. The dry blend and water was mixed in a mixer for 20 minutes. The resulting fibrous dough was extruded as in Example I employing a 2/1 screw turning at 50 RPM. Dough entering at 70°F and passed thru the extruder heated at 300°F and exited as continuous strip of product having a stringy unaligned fibrous texture with the appearance of crabmeat.

EXAMPLE X

Dehydrated meat meal (slaughter house scrap) at a level of 40% was blended with 45% wheat gluten and 15% defatted soy flour and mixed with sufficient water to bring the final dough moisture to 30%. This dough was processed as in Example I using a 2/1 screw at 60 RPM and a barrel temperature profile with maximum of 280°F. The final product, upon hydration, was aligned, fibrous, and dense, and resembled a much superior portion of meat (pot roast). This textural upgrading of inexpensive meat meals provides an improved form for use in animal foods (i.e. dog and cat foods).

EXAMPLE XI

The formulation employed in Example I was formed into a dough of 35% H_2O as is. The dough (fibrous when pulled) was frozen and chopped into small pieces in a mill for convenience in feeding an extruder. A screw, 2-1/2" diameter, having a 24/1 L/D was employed at 22 RPM. The volume reduction in the center flights of the screw was 4/1. The auger contained 4 constant volume, inlet flights, 10 flights reducing volume 4/1 and 10 constant volume, outlet flights. Channel depth was 0.48 inches for the inlet flights and 0.12 inches for the outlet flights. The barrel of the extruder was heated to 320°F at the inlet with the remaining sections heated to 350°F, 335°F and 340°F respectively. The frozen formulation was processed at approximately 150 lbs/hr and yielded a substantially unpuffed, continuous, highly aligned, fibrous product closely resembling the product of Examples I and II. Actual thickness of the strip was measured as 0.125 inches whereas theoretically it was 0.12 inches based on the depth of the outlet flights. This represents less than a 5% increase in volume.

EXAMPLE XII

A dry blend of ingredients containing by weight, 25% soy grits, 60% vital wheat gluten, 12.6% wheat flour, 2.0% salt and 0.4% cysteine hydrochloride was prepared.

The dry ingredients are blended with water to give a doughy mass of 30% (as is) water content. The dough is subdivided and the resulting pellets of material are fed into an extruder equipped with a 1.5/1 (i.e. 3/2) compression ratio screw (auger) fitted with a 150° torpedo. The screw is operated at 125 RPM. Material is fed into the screw at a rate sufficient to keep it full. The barrel of the extruder is heated to 180°C (356°F) while the die plate is heated to 150°C (302°F). A 3/16 inch diameter die opening is used. The extrudate is recovered and dried at 110°C (230°F) for four hours prior to evaluation. The resulting expanded product, when rehydrated in boiling water, simulated chicken white meat in appearance and texture. The dried extrudate, when soaked one-half hour at 50°C, hydrates to 2.0 g. H_2O/g. solids. The density is 0.72 g./ml.

The above example is repeated using a 25% moisture dough with similar results. Similarly cysteine hydrochloride is removed and similar results are obtained.

EXAMPLE XIII

The procedure followed in Example XII is repeated but a 5/1 compression ratio screw (auger) and a one-quarter inch diameter die opening are employed. The formulation processed easily to give an expanded product with fibrous texture. The density was 0.74 and the hydration was 1.7 g. H_2O/g. solids.

EXAMPLE XIV

The procedure followed in Example XIII is repeated using the same formulation and a 5/1 screw operating at 125 RPM with a 150° torpedo. A die having a 1/4" diameter opening is employed and heated to 120°C (248°F). The extruder barrel is heated to 150°C (302°F). Doughs having 25, 30 and 35% moisture are extruded with best results obtained at 30% moisture. The resulting products were expanded, having a fibrous texture, a density of 1.30 g./ml (absolute) and a hydration of 1.13 g. H_2O/g. solids.

COMPARATIVE EXAMPLE

The same formulation as Example XII is extruded in a conventional extruder with short head auger assembly with two hole insert die. The assembly consists of three screw sections (separated by two steamlocks): (a) nose cone screw, (b) screw, and (c) screw. The nose cone screw was modified by cutting slots back into the flight about 4". There was obtained typical appearing puffed texturized vegetable protein having a density ranging from 0.18 to 0.55 g/ml and a hydration ranging from 2.2 to 3.9 g. H_2O/g. solids. These products tend to be spongy with segments of fibrous structure which is randomly oriented relative to the direction of extrusion. The products prepared in Examples XII—XIV are superior in that the resulting ropes, issuing from the die, are less expanded and possesses a continuous, fibrous structure with a high degree of alignment parallel to the direction of extrusion.

WHAT WE CLAIM IS:—

1. A process for preparing a fibrous product simulating meat which comprises adjusting the moisture content of a ground mixture containing at least 35% heat coagulable protein on a dry basis to 20% to 65% water, blending to a dough, compressing the dough in a chamber formed by the channel of screw rotating with an outer wall heated to at least 250°F. in which the volume of the channel between flights of the screw is decreased at least 3/2 from feed to discharge of the chamber to simultaneously degas, densify, and elongate the dough and heat set the dough to a thermally coagulated fibrous condition and expelling the set dough while maintaining a pressure drop to atmosphere of less than 500 psi.

2. A process for preparing a fibrous product simulating meat which comprises adjusting the moisture content of a ground mixture containing at least 35% heat coagulable protein on a dry basis to 25% to 65% water, blending to a dough, compressing the dough in a chamber formed by the channel of a screw rotating within an outer wall heated to at least 250°C. in which the volume of the channel between flights of the screw is decreased at least 2/1 from feed to discharge of the chamber to simultaneously degas and densify the dough, elongate the dough and heat set the dough into a thermally coagulated fibrous condition and expelling the set dough from the chamber without use of die while maintaining a pressure drop below 100 psi without substantial puffing of the set dough and while maintaining the fibrous condition of the dough.

3. A process for preparing a fibrous product simulating meat which comprises adjusting the moisture content of a ground mixture containing at least 35% heat coagulable protein on a dry basis to 20 to 49% water by weight, and blending the mixture of a dough, compressing the dough in a chamber formed by the channel of an auger rotating within an outer wall heated to at least 250°F. in which the volume of the channel between flights of the auger is decreased at least 3/2 from feed to discharge of the chamber to simultaneously degas and densify the dough, elongate the dough and heat set it into a thermally coagulated fibrous condition and forcing

the set dough through a die wherein the pressure drop to atmosphere is less than 500 psi causing some expansion of the set dough and recovering a fibrous product which when dry has a density of greater than 0.65 g./ml. and a hydration of not more than 2 g. H_2O/g. solids when soaked 1/2 hour in water at 50°C.

4. A process according to any one of claims 1 to 3, wherein the proteinaceous material contains one or more of defatted soy bean, gluten and animal protein.

5. A process according to any one of claims 1, 2 or 4, wherein the dough contains a major amount of vegetable protein and the moisture of the dough is from 25% to 49% by weight.

6. A process according to any one of claims 1, 2, 4 or 5, wherein the volume is decreased by 2/1 to 5/1 and the temperature of heating is in excess of 250°F.

7. A process according to any one of claims 1, 2 or 4 to 6, in which the release of compression does not increase the dough volume by more than 10% and the time of heating is less than 3 minutes.

8. A process according to claim 7, wherein the volume increase after compression is less than 5%.

9. A process according to any one of claims 1, 2 or 4 to 8, where the dough contains 20% to 70% wheat gluten and soy flour.

10. A process according to any one of claims 1, 3 or 4, in which the volume is reduced by from 3/2 to 5/2 and the temperature of heating is in excess of 250°F.

11. A process according to any one of claims 1, 3 or 4 or 10, in which the compression is less than 200 psi and the time of heating does not exceed 3 minutes.

12. A process according to any one of claims 1, 3, 4, 10 or 11, in which the dough contains wheat gluten and soy flour.

13. A process for preparing a fibrous product substantially as hereinbefore described in Examples 1 to 11.

14. A process for preparing a fibrous product substantially as hereinbefore described in Examples 12 to 14.

15. A fibrous protein product when produced by a process according to any one of claims 1 to 14.

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